Claims

1. A composite tubular member for spooling in an open bore configuration onto a reel and for unspooling for deployment, said composite tubular member comprising

(a) a substantially fluid impervious pressure barrier layer,

(b) a composite layer formed of fibers and a matrix, said composite layer and said pressure barrier layer together constituting a wall of said tubular member,

(c) an energy conductor extending lengthwise along said tubular member and embedded in the wall of said tubular member, and

(d) a sensor mounted with the wall of said tubular member and connected for signal communication by way of said energy conductor, so that said sensor responds to an ambient condition of said tubular member and communicates on said energy conductor a signal responsive thereto.

2. A composite tubular member according to claim 1, wherein said sensor is integrally formed with said energy conductor.

3. A composite tubular member according to claim 1, wherein said sensor is disposed within the wall.

4. A composite tubular member according to claim 1, wherein said sensor is selected from the group consisting of acoustic sensors, optical sensors, mechanical sensors, electrical sensors, fluidic sensors, pressure sensors, temperature sensors, and chemical sensors.

5. A composite tubular member according to claim 4, wherein said optical sensor is an interferometric sensor.

6. A composite tubular member according to claim 4, wherein said optical sensor is an optical intensity sensor.

7. A composite tubular member according to claim 6, wherein said optical intensity sensor is selected from the group consisting of light scattering sensors, spectral transmission sensors, radiative loss sensors, reflectance sensors, and modal change sensors.

8. A composite tubular member according to claim 4, wherein said mechanical sensor is selected from the group consisting of piezoelectric sensors, vibration sensors, position sensors, velocity sensors, strain sensors, and acceleration sensors.

9. A composite tubular member according to claim 4, wherein said electrical sensor is selected from the group consisting of current sensors, voltages sensors, resistivity sensors, electric field sensors, and magnetic field sensors.

10. A composite tubular member according to claim 4, wherein said fluidic sensor is selected from the group consisting of flow rate sensors, fluidic intensity sensors, and fluidic density sensors.

11. A composite tubular member according to claim 4, wherein said pressure sensor is selected from the group consisting of absolute pressure sensors and differential pressure sensors.

12. A composite tubular member according to claim 4, wherein said temperature sensor is selected from the group consisting of thermocouples, resistance thermometers, and optical pyrometers.

13. A composite tubular member according to claim 1 wherein said sensor is embedded in said composite layer.

14. A composite tubular member according to claim 1 wherein said sensor is embedded in said pressure barrier layer.

15. A composite tubular member according to claim 1 wherein said sensor is positioned between said pressure barrier layer and said composite layer.

16. A composite tubular member according to claim 1 wherein said sensor is mounted to the inner surface of said composite tubular member.

17. A composite tubular member according to claim 1, further comprising at least one additional sensor arranged for signal communication by way of said

energy conductor, said sensor and said additional sensor forming a set of sensors distributed along the length of said energy conductor.

18. A composite tubular member according to claim 17, wherein said sensor and said additional sensor are positioned at different locations in the wall of said composite tubular member.

19. A composite tubular member according to claim 17, further comprising means for forming a second energy conductor embedded in the wall of said tubular member, said sensor and said additional sensor being connected in parallel between said energy conductor and said second energy conductor means.

20. A composite tubular member according to claim 1, further comprising a second energy conductor embedded in the wall of said tubular member and at least one additional sensor mounted with the wall of said tubular member and arranged for signal communication by way of said second energy conductor.

21. A composite tubular member according to claim 1, wherein said energy conductor extends helically along the length of said composite tubular member.

22. A composite tubular member according to claim 1, further comprising an axially extending second energy conductor embedded in the wall and disposed diametrically opposite from said energy conductor.

23. A composite tubular member according to claim 1, wherein said energy conductor is selected from the group consisting of a hydraulic medium, a pneumatic medium, an electrical medium, and an optical medium.

24. A composite tubular member according to claim 23, wherein the optical medium is an optical fiber selected from the group consisting of single-mode fibers, multimode fibers, or plastic fibers.

25. A composite tubular member according to claim 1, wherein said pressure barrier layer is formed of a material selected from the group consisting of metals, polymers, and metal/polymer composites.

26. A composite tubular member according to claim 25, wherein said pressure barrier layer is a polymer selected from the group consisting of polyvinylidene fluoride, ethylene tetrafluoroethylene, cross-linked-polyethylene, polyamide, polyethylene, and polyester.

27. A composite tubular member according to claim 1, further comprising an inner protective layer formed of fibers embedded in matrix, said inner protective layer being positioned internally of said pressure barrier layer and said composite layer being positioned externally of said pressure barrier layer.

28. A composite tubular member according to claim 1, wherein said fibers forming said composite layer include a group of fibers helically oriented along the length of said tubular composite member.

29. A composite tubular member according to claim 28, wherein at least 80 percent of said group of fibers, by fiber volume, are helically oriented at an angle between 30 degrees and 70 degrees relative to the longitudinal axis of the composite tubular member, such that said composite tubular member can be spooled on the reel in an open bore tubular configuration.

30. A composite tubular member according to claim 1, wherein the maximum tensile strain of said composite tubular member when spooled on a reel is 0.25 percent.

31. A composite tubular member according to claim 1, wherein the modulus of elasticity of said composite tubular member is greater than 100,000 psi.

32. A composite tubular member according to claim 1, further including an outer pressure barrier layer enclosing said composite layer and wherein said composite layer encloses said fluid impervious pressure barrier layer, said outer pressure barrier layer resisting penetration of fluids into said composite tubular member.

33. A composite tubular member according to claim 1, further comprising an outer protective layer disposed externally to said composite layer, said outer protective layer providing wear resistance to said composite tubular member.

34. A composite tubular member according to claim 33, wherein said outer protective layer is of material selected from the group consisting of ceramics, polymers, filled polymers, fiber composites, silicas, fluorinated polymers, and metals.

35. A composite tubular member according to claim 33, further comprising an outer pressure barrier layer positioned between said outer protective layer and said composite layer, and wherein said composite layer is positioned externally of said fluid impervious pressure barrier layer

36. A composite tubular member according to claim 35, further comprising an inner protective layer positioned internally of said fluid impervious pressure barrier layer.

37. A composite tubular member according to claim 1, further comprising an interface disposed at an end of the composite tubular member and connected with said energy conductor for coupling said signal from said energy conductor with a signal processor when connected with said interface.

38. A composite tubular member for spooling in an open bore configuration onto a reel and for unspooling for deployment, said composite tubular member comprising

(a) a substantially fluid impervious pressure barrier layer,

(b) a composite layer formed of fibers in a polymer matrix, said composite layer and said pressure barrier layer together constituting a wall of said tubular member and maintaining a generally cylindrical shape when deployed and spooled on a reel,

(c) an energy conductor extending lengthwise along said tubular member and embedded in the wall of said tubular member, and

(d) a sensor disposed in the wall of said tubular member and connected for signal communication by way of said energy conductor, so that said sensor responds to an ambient condition of said tubular member and communicates on said energy conductor a signal responsive thereto.

39. Interfacing apparatus for a composite spoolable tubular member that has at least one fluid passage and that has a set of one or more energy conductors, said interfacing apparatus comprising a combination of

(a) pressure sealing means engagable with the spoolable tubular member for fluid communication with the fluid passage therein and for maintaining a pressure differential between the passage and ambient conditions,

(b) load bearing means engagable with the spoolable tubular member for the transfer of a mechanical load between the spoolable tubular member and the interfacing apparatus, and

(c) an energy coupler for signal communication with at least one energy conductor of the spoolable tubular member,

said interfacing apparatus being further arranged for removable and replaceable engagement with further equipment.

40. A composite tubular member for spooling onto a reel and for unspooling for deployment, said composite tubular member comprising

an inner protective layer,

a substantially fluid impervious pressure barrier layer,

a composite layer formed of fibers and a matrix, said composite layer and said pressure barrier layer and said inner protective layer together constituting a wall of said tubular member.

41. A composite tubular member according to claim 40, wherein said inner protective layer is formed of fibers embedded in a polymer matrix.

42. A composite tubular member according to claim 40, wherein said inner protective layer is formed of metal or a metal/polymer composite.

43. A composite tubular member according to claim 40, further including an outer pressure barrier layer enclosing said composite layer and wherein said composite layer encloses said fluid impervious pressure barrier layer, said outer pressure barrier layer resisting penetration of fluid into said composite tubular member.

44. A composite tubular member according to claim 43, further including an outer protective layer disposed externally to said outer pressure barrier layer.

45. A composite tubular member according to claim 44, wherein said outer protective layer is formed of fibers embedded in a polymer matrix.

46. A composite tubular member according to claim 54, wherein said inner protective layer is formed of metal or metal/polymer composite.